

G8JNJ

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Active antennas and receive systems - overview

One of the key factors influencing what you can actually hear, is the receive system noise figure, and your receive site noise floor. In most cases modern amateur HF receivers have a sufficiently low enough value of noise figure, that the main factor which limits what can be heard, will be the antenna and the amount of unwanted noise present at the receive site that masks the wanted signals.

There are several factors that influence the amount of noise entering the receiver input. One is how much noise is inadvertently picked up and coupled in by the feed line, by mechanisms such as poor screening or unwanted common mode current, which we can usually do something about. The other is how much noise is picked up by the actual antenna, and is directly competing with the wanted signal. The only way we can improve this is to use an antenna that has some directivity that favours the wanted signal, and as much as possible rejects the unwanted noise.

The actual gain of an antenna is less important for receive purposes on the lower frequency bands, as it is the Signal to Noise Ratio that it produces that is the critical factor. On the LF bands the natural noise floor is very high, even in the quietest rural locations. This allows electrically small antennas such as the PA0RDT active E-Probe, to be able to produce good results on the VLF <100kHz bands.

On the HF and LF bands, there is a differing requirement between transmit antennas. Transmit antennas are generally required to be as efficient as possible, and have some gain in order to maximise the amount of power being radiated in the required direction. Whereas receive antennas just need to be able to produce the best possible Signal to Noise ratio. These are differing requirements, and there is not always reciprocity between the two. A good transmit antenna is not necessarily a good receive antenna.

However as we go up in frequency the level of natural noise decreases, and it is about 30dB lower at 30MHz in comparison to 1MHz. A receiver with a noise figure of about 13dB, and using a typical dipole type antenna, will still have an adequate level of performance at 30 MHz. In fact in an urban environment, where the local noise floor is likely to be much higher, then a receiver with a much higher Noise Figure would still be perfectly adequate.

Once we get onto the low VHF bands and higher in frequency then things start to change. The natural noise floor is lower and tends to be predominantly extra terrestrial galactic noise, and receiver noise figures starts to become more relevant. Modern semiconductors can now achieve <1dB noise figures even on the microwave bands, and the only way to improve reception any further is once again to increase the directivity of the antenna, which usually equates to more gain in the desired direction. Because if this, there tends to be a lot more reciprocity between transmit and receive antennas, and a good transmit antenna will generally also be a good receive antenna. The antenna gain and directivity produce a narrow 'beam' in one direction, and this can both maximise the transmitted radiated power in the required direction, and produce additional receive gain in the required direction, in addition to rejection of unwanted noise and interference from other unwanted directions.

There is of course still the problem of terrestrial interference, but an antenna half power beam-width of just a few degrees at VHF / UHF / MicroWave frequencies, is a lot better at rejecting this than say a HF beam or worse still a wire antenna that may have a half power beam-width of several tens of degrees.

Once we start looking up to the heavens with our antennas, and leave terrestrial interference behind, then we really start pushing the boundaries. The natural noise floor becomes really low, as the cold dark vastness of space starts to approach temperatures of zero Kelvin. So for amateur Earth Moon Earth (EME) operation, there is an enormous technical challenge to be able to produce a receive system with a low enough Noise Figure, to be able to hear the very weak signals that are reflected off of the lunar surface, that just about make it all the way back to the earth. If you have a very big budget, like NASA, you can do even better with your antenna system, and receive weak signals from spacecraft outside of our solar system.

For the average hobbyist, even quite mediocre receivers are usually still good enough to hear just about everything a very expensive top of the range receiver can. The only main difference is the ability to withstand interference and overload from nearby very strong signals. Which is usually only of concern to big gun contest operators, on good sites with very large antenna arrays. Something that most of us can only dream of.

Active Antennas

Active antennas can provide very good receive performance from a physically small structure. They do this by using an amplifier to make up for the lack of gain

However there are some design constraints.

- Impedance matching of the antenna element to 50 Ohms over a wide frequency range
- Low noise amplification. Ideally 10dB lower than the received atmospheric noise level
- Good power handling to avoid intermodulation distortion and the production of unwanted spurious signals.

If these factors can be overcome. The design should work as well as (or in some cases better than) a full sized antenna. However this is a tall order, as strong signal handling is the main issue with low noise amplifiers, especially when used in a broadband configuration in the presence of strong local signals (usually broadcast stations).

Generally speaking Active Antennas tend to fall into one of three categories.

Monopole or Whip

These are unbalanced antennas fed against a ground reference.

- For - Very compact
- Against - Very difficult to prevent unwanted noise and interference from being picked up by the feed coax

Dipole

These are balanced antennas with two active elements, which if designed well can be extremely effective over a very large frequency range.

- For - Compact, balanced design helps reject unwanted noise and interference
- Against - Needs very good balance in order to prevent unwanted common mode signals overriding the wanted differential mode signals

Loop

These are balanced antennas which generally use a vertical circular loop of approximately 1m in diameter, although they can be horizontal and / or much larger.

- For - Inherently balanced design, low value of feed point impedance helps reject unwanted noise and interference
- Against - Limited frequency range, loop conductor needs to be quite large in order to obtain the best results

Note that with all types of active monopole antennas the performance is very much determined by the height of the antenna above ground and the amount of unwanted noise that is coupled into the connecting cable which forms part of the antenna.

These webpages explain why this is so, and how to improve the performance by careful routing of the coax cable.

Fundamentals of the MiniWhip antenna <http://www.pa3fwm.nl/technotes/tn07.html>

Grounding of MiniWhip and other active whip antennas <http://www.pa3fwm.nl/technotes/tn09d.html>

Here is a selection of some of the better designs that can be found on the web.

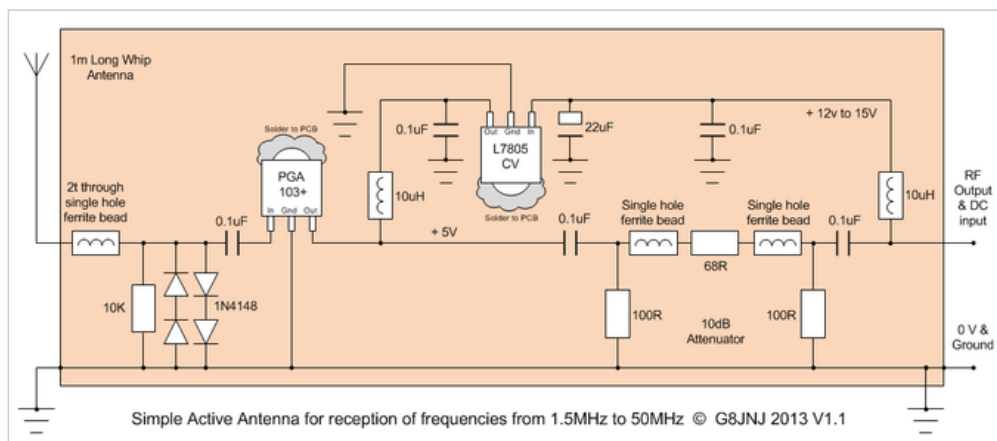
G8JNJ Active Monopole Antenna

The following is a very simple design for an Active monopole antenna.

It uses a Mini-Circuits PGA-103+ which is a new type of wideband amplifier built using E-PHEMT technology. Which is specified to operate over the frequency range of 50MHz to 4GHz. Below 400MHz this device provides extremely high dynamic range (IP1 +20dBm & IP3 +36dBm), moderate gain of 20dB with a very low noise figure (0.5dB).

The reason Mini-Circuits doesn't specify an operating frequency below 50MHz. Is that the input impedance of the device becomes progressively higher as frequency decreases. So it no longer has a stable 50 Ohm input impedance, but one that is in the region of 1000 Ohms. This makes it ideal for use in an active antenna. Especially for frequencies below 50MHz.

Here is the circuit I have developed.



I have included a 10dB resistive attenuator on the output. This is necessary to reduce the overall gain of the circuit, and provide a 50 Ohm resistive termination for the device. Which can otherwise become unstable when connected to an input load that is highly reactive. Such as a short whip antenna. With a 1.2m thin wire or 1m telescopic rod. The overall gain is similar to that of a correctly terminated 10m vertical antenna.

See this Mini-Circuits [application note](#) for more details WRT device stability on frequencies lower than 100MHz

As the device can provide a saturated output of more than 100mW. The attenuator also reduces the maximum amount of RF power the circuit can deliver to any receiver that may be connected.

Note that I have incorporated ferrite beads, in order to gradually reduce the gain above 50MHz. It is possible to build the circuit without the ferrite beads. But the antenna may suffer from overloading due to FM, DAB, TV and Mobile Phone transmitters. As the device provides gain up to and beyond 4GHz. With a suitable antenna and filters it is perfectly possible to build an active antenna with very good performance over the frequency range 1.5MHz to 1.5GHz.

As a further experiment, I tried using the PGA-103+ directly at the feed point of a 'Double Discone' style antenna similar to this model

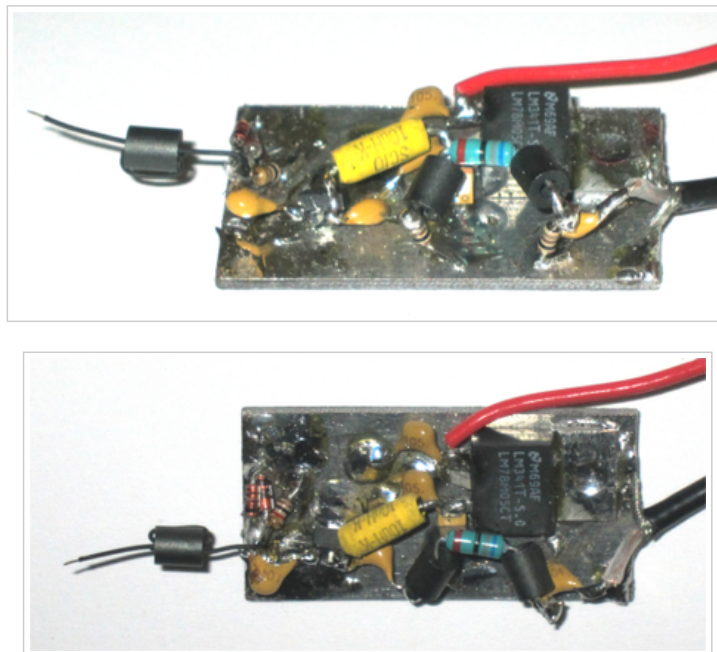
<https://sigmaeurocomm.co.uk/product/double-discone-scanner-base-station-antenna-aerial/>

However as expected, it suffered quite badly from overload due to the large number of transmitters in the local (urban) area. I'm sure it's possible to get this combination to work much better. But further experimentation is required. One thought is to try applying some negative feedback in order to reduce the overall gain slightly and further increase linearity. Placing two sets of two diodes in series on the input rather than just a pair of back to back diodes. Would also help cope with the higher signal levels from the larger antenna, before starting to enter the conduction region.

I chose to feed power to the circuit via the coax. So a hybrid Tee is required to insert the DC supply, and separate out the RF at the receiver end of the coax. I simply used another 10uH inductor and 0.1uF DC blocking capacitor. In a similar arrangement to that shown on the output of the circuit. Of course you can feed DC directly into the circuit if you wish. Just disconnect the 10uH inductor from the RF output and connect it to the DC supply instead.

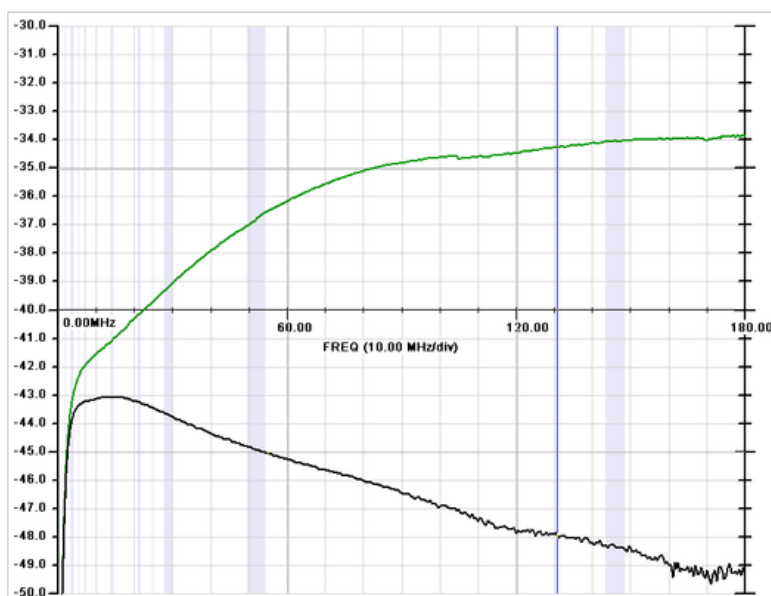
Note that the PGA-103+ and 5V regulator need adequate heatsinking. I soldered both devices directly to the copper clad circuit board. When soldering the PGA-103+ onto the board, I held all three pins with a pair of flat nosed pliers. This helped reduce the possibility of ESD damaging the device, and provided additional heatsinking during (and immediately after) application of the soldering iron. I mounted the device at an angle of about 20 to 30 degrees up from the surface of the board. This makes it much easier to solder to the input and output pins without shorting to the copper groundplane of the PCB.

Here are a couple of photos of the circuit built up 'dead bug' style on a scrap of PCB material.

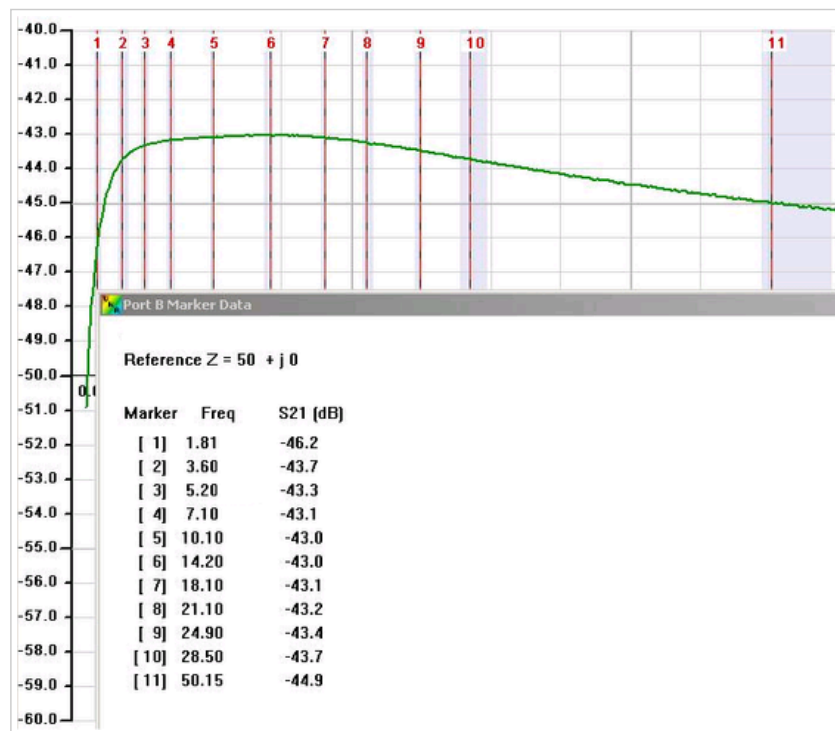


In the following amplitude / frequency graph was measured with a VNA 2180. The level into the circuit has been attenuated by 40dB in order to ensure that the amplifier is operating well below saturation. The input to the circuit has also been fed through a 15pF capacitor. This is in order to simulate the impedance presented to the circuit by the whip antenna. However it does reduce the signal level into the circuit. So the actual overall gain is higher than indicated in the graphs.

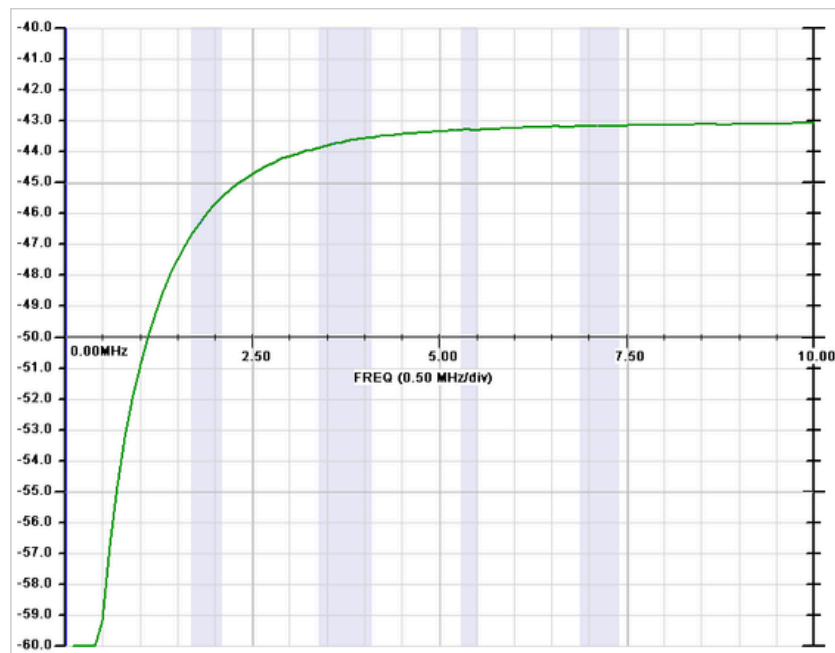
The frequency response of the circuit without ferrite beads is shown in green. The response with ferrite beads is shown in black.



Next a graph showing the frequency response below 50MHz in more detail. This plot has been taken with the ferrite beads fitted. The overall frequency response is within +/- 1.5dB over the frequency range 1.8MHz to 50MHz.



The next graph shows that the circuit has a very steep roll off below 1.5MHz. This helps to minimise overload from MF broadcast stations.



The overall performance of the antenna over the frequency range 1.5MHz to 50MHz is very good. As the moderate gain, good linearity and very low noise figure of the device makes it ideal for this purpose. This is one of the easiest to construct, and best performers of all the active monopole designs I have built so far .

Note that the lower frequency limit is mainly defined by the value of inductors used in the power injection circuit. If you wish to set a much lower frequency limit substitute the 10uH chokes for 100uH (or greater).

Kent Britain, WA5VJB, suggested that I could further simplify my active antenna circuit, by omitting the complicated DC injection and regulator circuit and replacing it with a resistive load.

I took his advice and modified the output attenuator circuit to act as a load resistor and voltage dropper, as shown below.

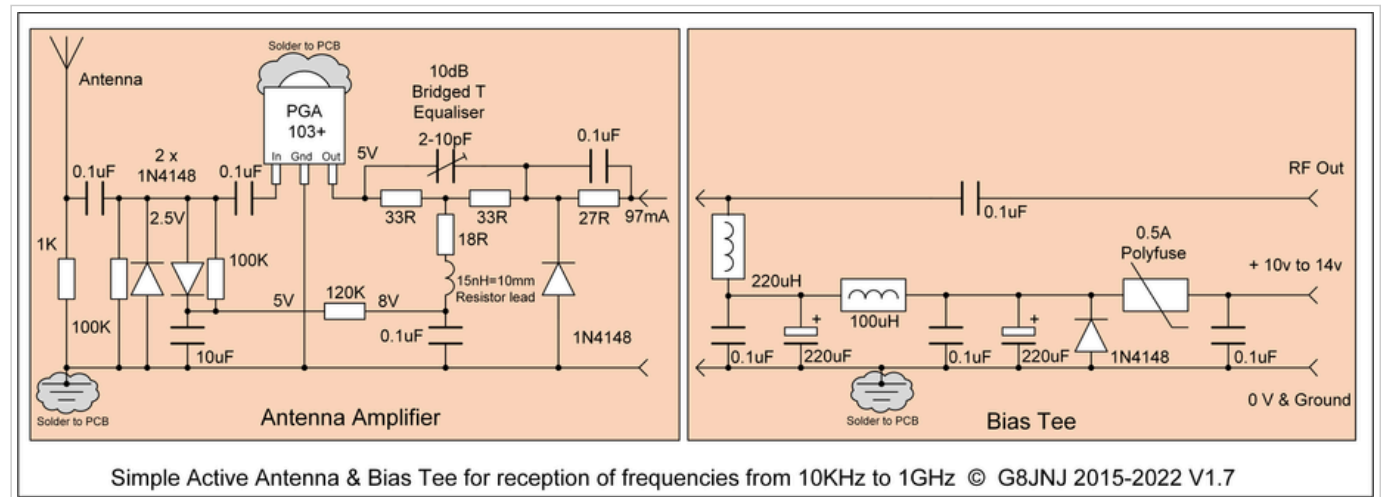
In addition I have modified the attenuator circuit to become a bridged T equalisation network, which gives a very flat overall amplitude / frequency response (+/-1dB) from 30MHz to 1GHz.

Adjust the 15nH inductor and 2-10pF trimmer capacitor for the flattest frequency response.

The resistor values in the 10dB attenuator stage are a compromise between readily available resistors, the required amount of attenuation and setting the correct DC bias conditions. In order to perform the latter, I have had to add an extra by-passed resistor in series with the RF output / DC input.

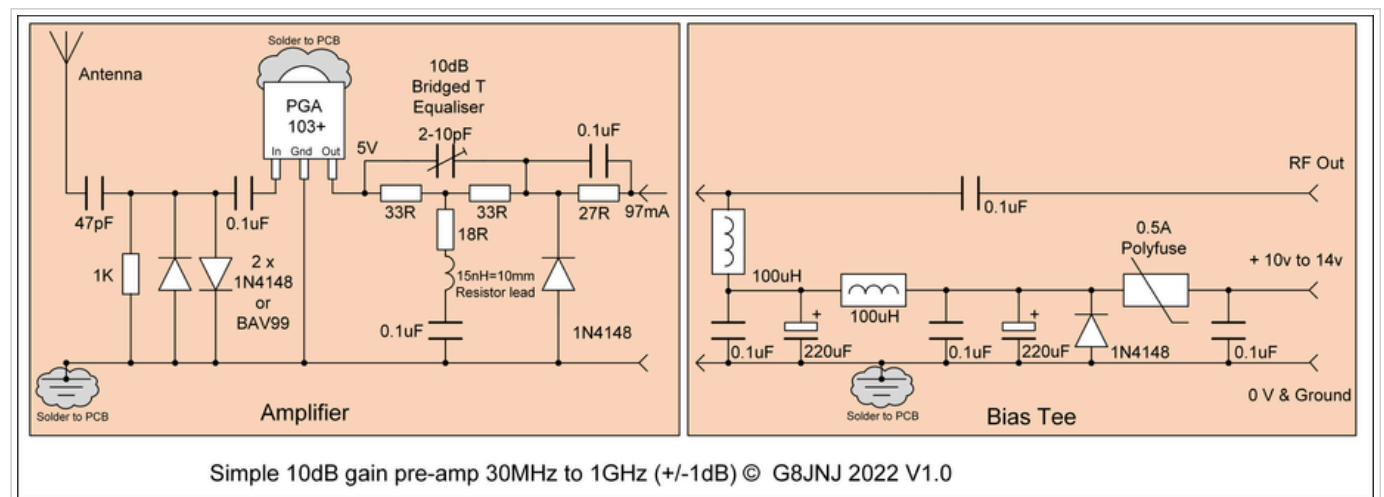
Note that the resistors used in the output attenuator network are required to dissipate some power, so 1/3 watt rated components should be used.

The input protection diodes are reverse biased at a midpoint of 2.5v. This is required in order to minimise their IMD contribution, as the circuit input impedance is relatively high.

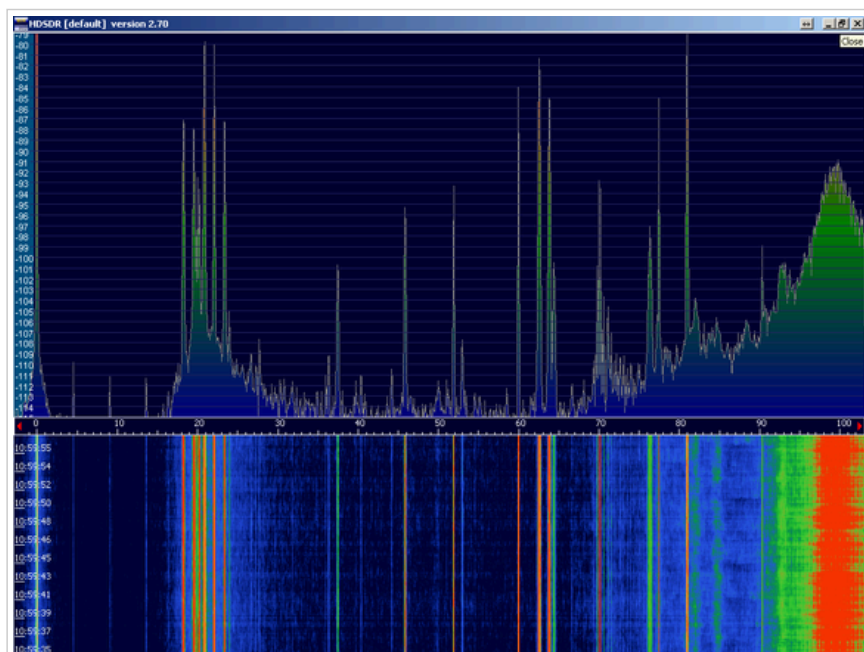


If you wish to use the circuit just as a broadband preamp covering the frequency range 30MHz to 1GHz, then this version may be a better option.

The input diodes no longer need a DC bias, as the source impedance is 50 Ohms, and they will not add further IMD beyond the contribution from the PGA-103+ (that I could measure).



Here's a screen grab from HSDR showing the DC to 100KHz spectrum using the active antenna and a RTL 820T2 dongle in direct sampling mode.



Note that the height of the antenna above ground makes a difference to the output signal level, but once you get outside the local noise field it does not make much further difference to the S/N ratio.

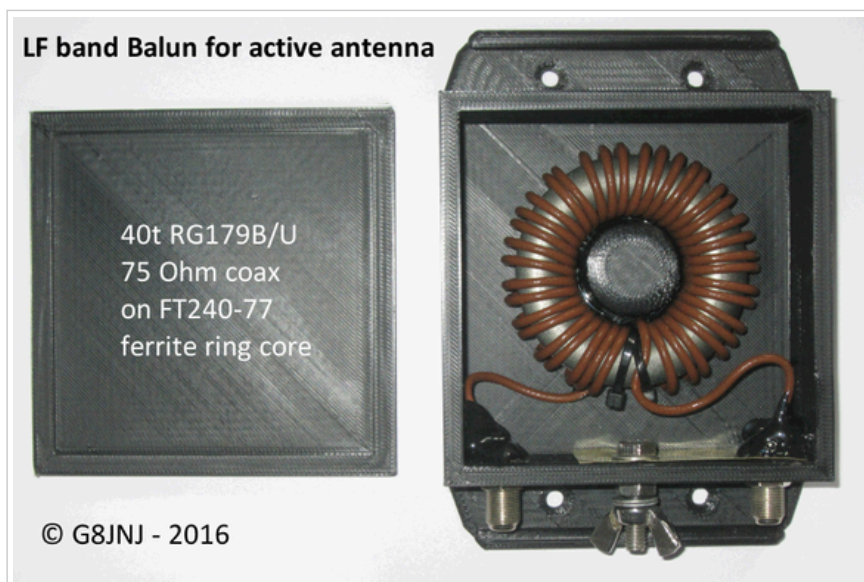
The coax forms part of the antenna system, so it has to be routed away from noise sources.

As the antenna is a high impedance device the feed coax needs a good ferrite choke Balun wound on something like type 77 Mix for the LF bands, and (this bit is crucial) a good separate earth bond, not associated with the house mains supply, on the antenna side of the choke which should be mounted at ground level.

Here's a picture of a choke Balun that I built for use with the SUWS WEB SDR. The case has been 3D printed and has fixing tabs for tie wraps and holes for screw mounting. It also has a small hole near the connectors to help prevent a build up of condensation inside the case.

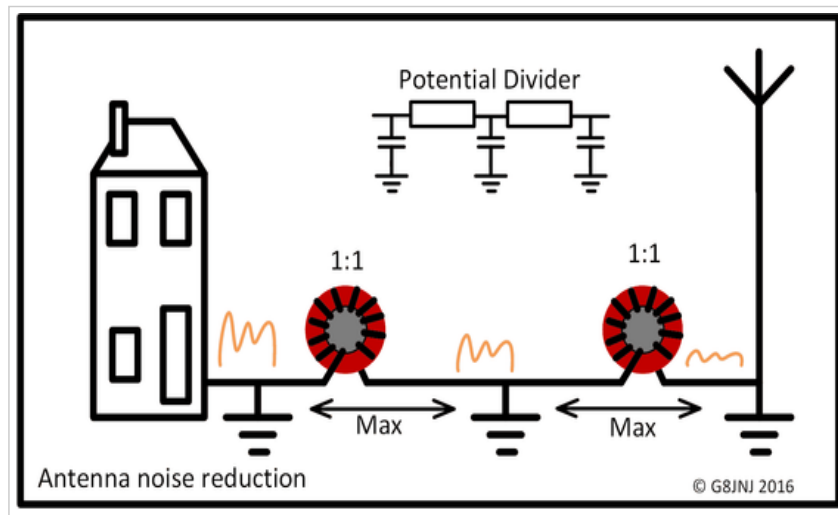
The number of turns has been optimised in order to help reduce noise pickup in the 300-500KHz NDB band.

The SDR has a 75 Ohm input and the satellite TV coax is also 75 Ohm, which is why the Balun is also wound with 75 Ohm coax.

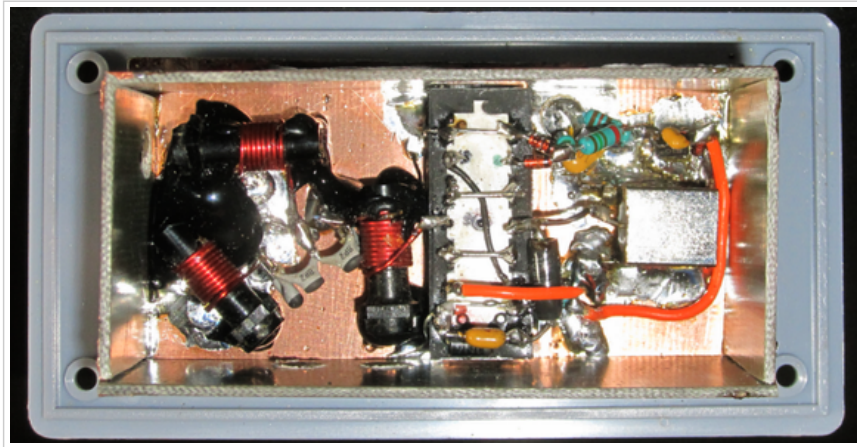


The common mode impedance presented by the choke on it's own is not sufficient to suppress all the noise induced onto the outer of the coax, so the addition of an earth bond (and also running the coax along the ground) is necessary in order to provide a preferred lower impedance route to ground rather than through the choke. 75 Ohm foil screened and foam insulated Satellite TV coax is the cheapest option for long cable runs.

My preferred solution is to put the antenna up a tree as far away from the house as possible, run the coax down the tree to the choke and earth spike at the base of the tree and then run the rest of the coax back to the shack either along the ground, or better still buried a few inches below the soil, something like this.



I've also used the same PGA-103+ circuit to build a mast head pre-amplifier for use with the SUWS WEB SDR on 50MHz. But in this case I added a simple Band pass filter to the input and also a by-pass relay, so that I could switch the pre-amp out of circuit if required.



Obtaining the PGA-103+ from suppliers

The PGA-103+ device can be obtained on ebay or directly from Mini-Circuits in small quantities >20. The device is very sensitive to static and the application of a soldering iron for prolonged periods. So I'd advise getting a few extra ones just in case.

Further details of the PGA-103+ can be found on the Mini-Circuits website at <http://217.34.103.131/pdfs/PGA-103+.pdf>

Most of the parts are easy to obtain, perhaps with the exception of the main RF device in some parts of the world.

Mini-Circuits order page <http://217.34.103.131/MCLStore/ModelPriceDisplay?13727481128460.1842254836967835>

Alternatively you could buy a kit and modify it.

<http://www.g4ddk.com/PGA103amp.pdf>

Order details about 1/2 way down this page <http://www.g4ddk.com/> cost is £12 for all the bits apart from a 5v regulator.

eBay also have some different versions of kits from time to time.

http://www.ebay.co.uk/itm/PGA-103-low-noise-amplifier-kit-VHF-UHF-uW-/121132254874?pt=LH_DefaultDomain_0&hash=item1c340b869a

Minikits in Australia also stock some parts

http://www.minikits.com.au/PGA-103-Amplifier?filter_name=pga

http://www.minikits.com.au/PGA-103?filter_name=pga

Other Active monopole antennas

If you wish to read an overview of the design considerations required to make an effective active monopole

"A High Performance Active Antenna for the High Frequency Band" is a good starting point.

<https://www.dst.defence.gov.au/sites/default/files/publications/documents/DST-Group-TR-3522.pdf>

The following designs are some of the more popular offerings.

PA0RDT mini-whip voltage probe

http://dl1dbc.net/SAQ/Mwhip/Article_pa0rdt-Mini-Whip_English.pdf

This is a very simple compact antenna. I have built two so far. One is now working in the garden about 5m away from the house, but needs elevating higher off the ground than the current 1.5m. It picks up a lot of noise when close to the house.

Like all E probe antennas it is very prone to common mode noise. This is very difficult to choke off the feed line due to the high input impedance of the design. I may need to experiment and build a balanced version to see if I can reduce noise pickup.

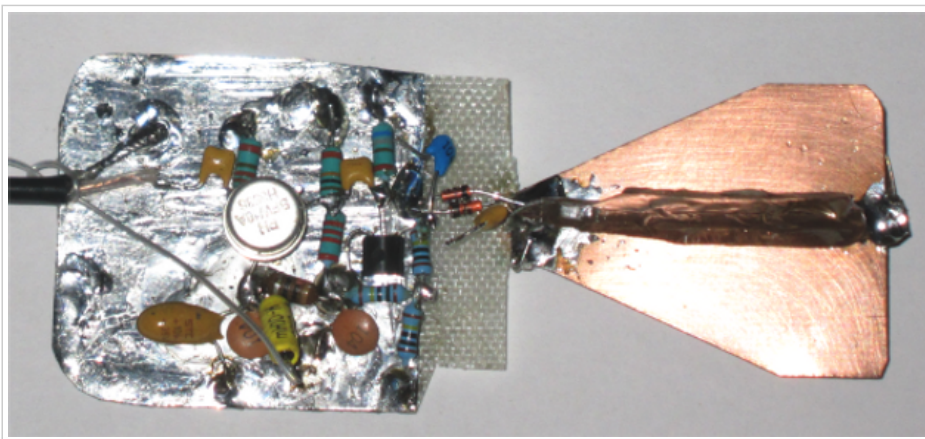
The frequency response of the version without the 10uH series choke connected between the antenna and the amplifier is very flat $\pm 0.5\text{dB}$ from 50KHz to 30MHz. Adding the choke lifts the response at 30MHz by approx. 10dB. The upper frequency limit seems to be constrained by the input capacitance of the amplifier. Modifying the shape of the antenna element to increase its self-capacitance improves the HF performance without degrading performance at the LF end of the operating range but more testing needs to be done.

Note that it's not a good idea to add back to back protection diodes across the amplifier input of these high impedance designs (as shown in the picture below). If you do want to add diodes connect them in series so that they are reverse biased between ground and +ve supply rail with the junction connected to the amplifier input.

I measured the IMD performance of this design (without input protection diodes) to be OIP2 = +75dBm & OIP3 = +32dBm

Owen Duffy has performed a detailed analysis of this antenna. Including the influence on it's performance by the length of feed cable and other factors associated with its installation.

<http://owenduffy.net/antenna/PA0RDT-MiniWhip/>



There are also a number of kit versions available if you want to make something that looks a bit more professional.

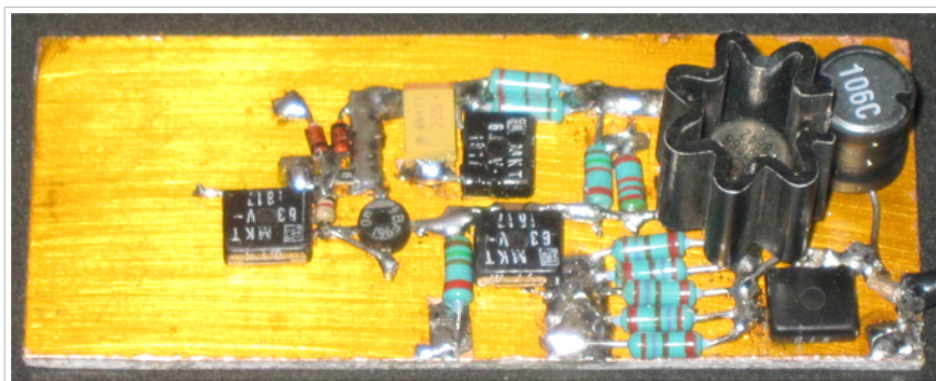
<http://www.pa0nhc.nl/Miniwhip/indexE.htm>

<http://huprf.com/huprf/e-field-probe-active-antenna/>

Since originally building this antenna, I have found another updated version designed by PA0NHC, who suggests that his design may offer better performance.

http://www.pa0nhc.nl/Miniwhip/pa0nhc_miniwhip.htm

Prototype built on copper board on top of insulating layer of self-adhesive Kapton tape.



However the gain of the PA0NHC antenna seems to be about 4dB less than the PA0RDT design, which would further contribute to an improvement in the intermodulation performance.

The graph below shows the measured gain frequency relationship of the two types of antenna. In the case of the PA0NHC antenna I also experimented with changing the value of the 0.1uF coupling capacitors to 10uF in order to decrease the lowest operating frequency. This would also produce a similar result with the PA0RDT design if you are interested in the reception of frequencies below 50KHz with these antennas.

Note that in order to achieve the reception of such low frequencies, the DC injection / RF blocking choke in the antenna circuit and Bias Tee also need to be increased in value from 470uH to 10mH. Ensure that any chokes used for this purpose have a low value of resistance and a high enough current rating. I used a FASTRON part number 77A-103M-00 10mH Inductance, 14.4 Ohms DC resistance and 300mA current rating, which is stocked by CPC.

<http://cpc.farnell.com/fastron/77a-103m-00/suppression-coil-leaded-10mh/dp/FT00801>

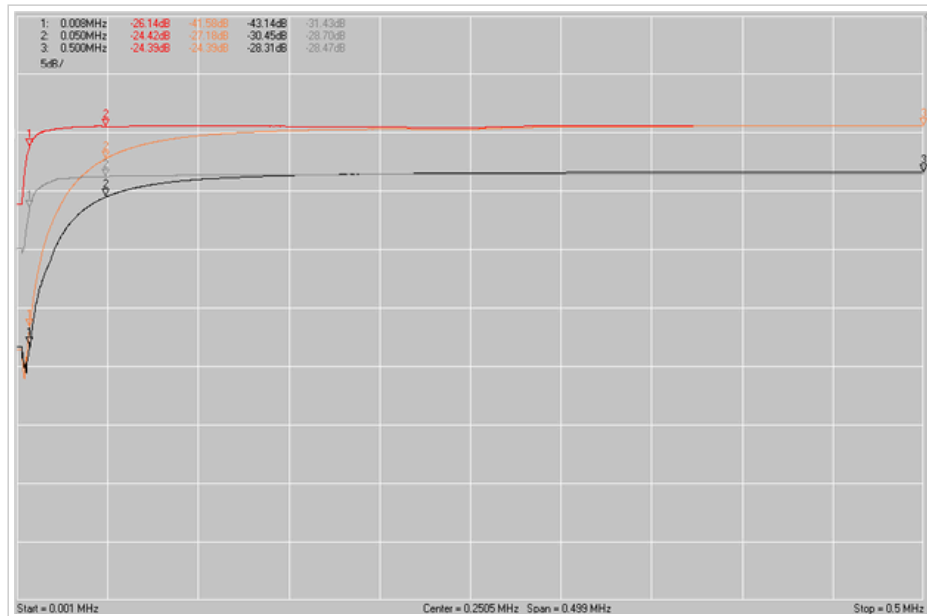
The plots shown below were taken with 10mH choke inductors.

Orange trace = PA0RDT with simulated 20pF input load and using standard 0.1uF coupling capacitors

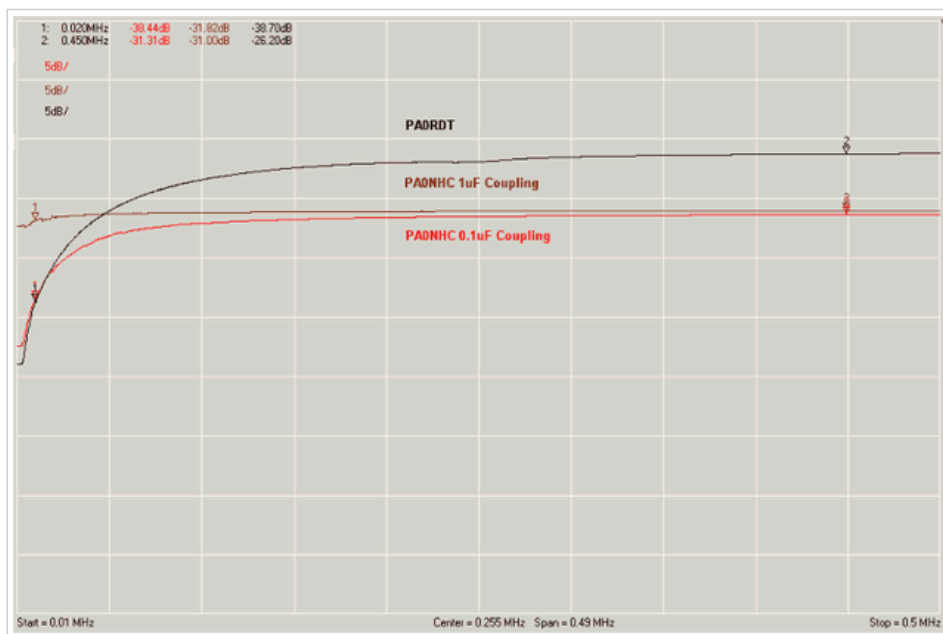
Red trace = PA0RDT with simulated 20pF input load and using 10uF coupling capacitors

Black trace = PA0NHC with simulated 20pF input load and using standard 0.1uF coupling capacitors

Grey trace = PA0NCH with simulated 20pF input load and using 10uF coupling capacitors



In practice 1uF coupling capacitors seem to provide the best compromise between acceptable low frequency performance and the rejection of excessive levels of 50Hz mains hum.

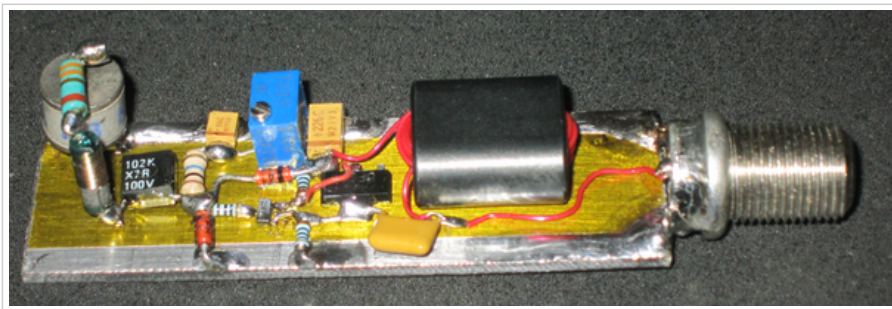


PA3FWM Mini-Whip

Pieter, PA3FWM has produced another updated Mini-Whip design based on PA0RDT's original.

<http://www.pa3fwm.nl/projects/miniwhip/>

This is now in use on the University of Twente WEB SDR <http://websdr.ewi.utwente.nl:8901/>



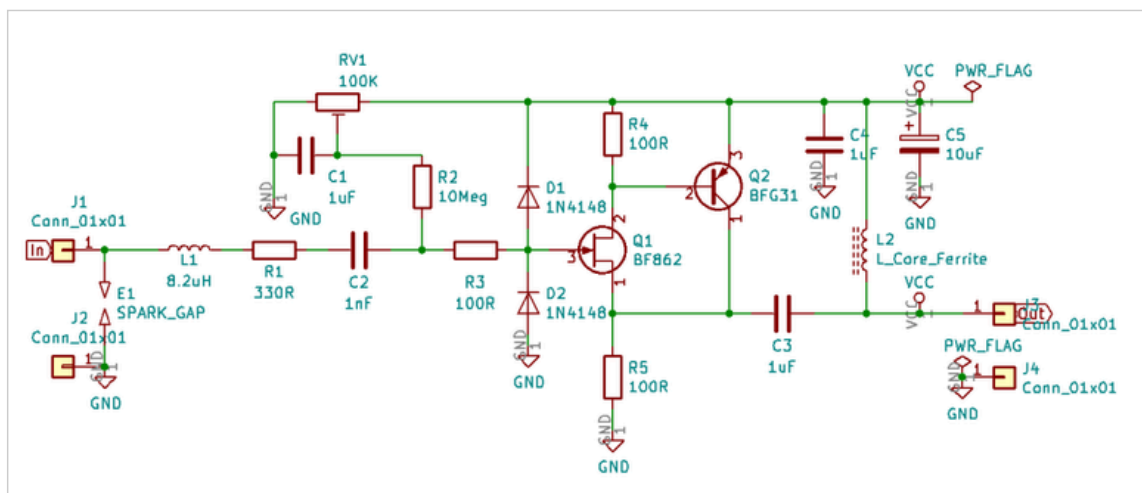
As you can see above I've added some extra components to Pieter's design.

This is to add some input protection and also to allow adjustment of the bias current for best IMD performance.

I measured it to have OIP2 = +80dBm & OIP3 = +33dBm so it provides a slightly better IMD performance than the original PA0RDT design.

This means that it is good enough to use with a 1m whip antenna in place of the plate or small wire loops that have been used by Pieter.

Here is the circuit I'm currently using.



RA0SMS Mini-Whip

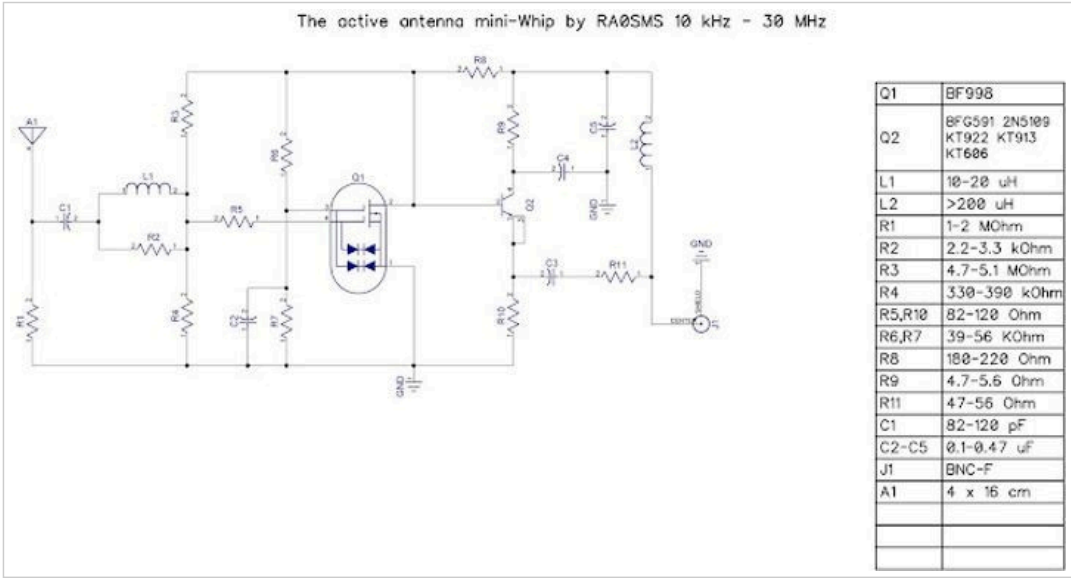
This is another variation on the PA0RDT design but is sold as a complete unit on E-Bay.

<http://www.ra0sms.ru/p/the-active-antenna-mini-whip-10-khz-30.html>

I haven't had a chance to build or test this design so far, so I can't comment on its performance in comparison to other similar offerings.

Unfortunately the published specification does not mention the IMD performance.

However I have previously built other E-Probe antennas using dual gate FET's instead of JFET's and I found that the IMD performance was not as good.



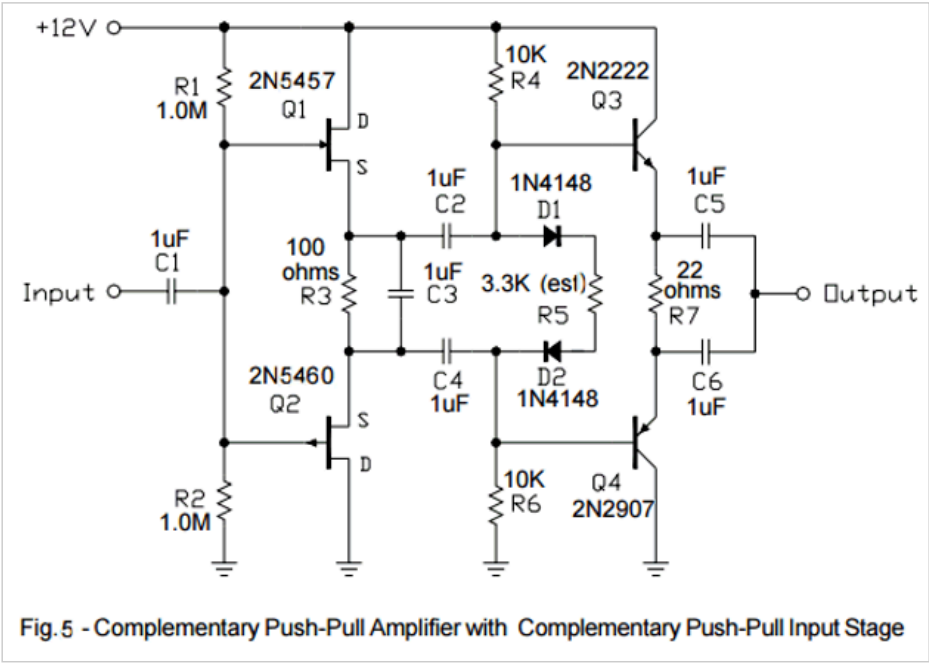
Chris Trask

has produced a number of excellent active antenna amplifier designs. Some of which have been recently updated as a result of feedback from constructors such as myself.

<http://home.earthlink.net/~chrstrask/Complementary%20Push-Pull%20Amplifiers.pdf>

<http://home.earthlink.net/~chrstrask/Active%20Mongpole%20Amplifier.pdf>

I have built the circuit shown in Figure 5 in the first document.



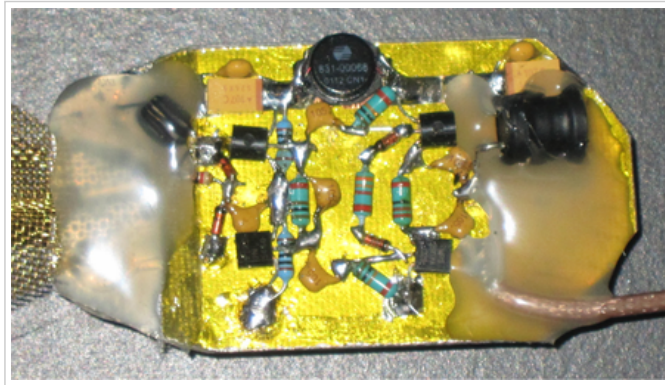
This works very well and doesn't require any special transformers. Using the component values shown in the circuit above, it has a flat frequency response from less than 5KHz up to and beyond 30MHz.

The measured IMD performance was OIP2 = +59.1dBm and OIP3 to be = +43.8dBm which is about 12dB better than PA0RDT.

So it is possible to use a slightly larger whip antenna, which will provide improved S/N performance without introducing a significantly higher level of intermodulation products.



Here is another version using a larger DC bias Tee choke and 1uF coupling capacitors, which has been optimised for the VLF bands.



I'm currently using this design for LF band reception on the [SUWS Farnham WEB SDR](https://www.suws-farnham.co.uk/web-sdr/).

This picture shows the antenna as installed at the SDR site.

The external housing is made from 50mm diameter plastic water pipe with 3D printed end caps and mounting clamp.



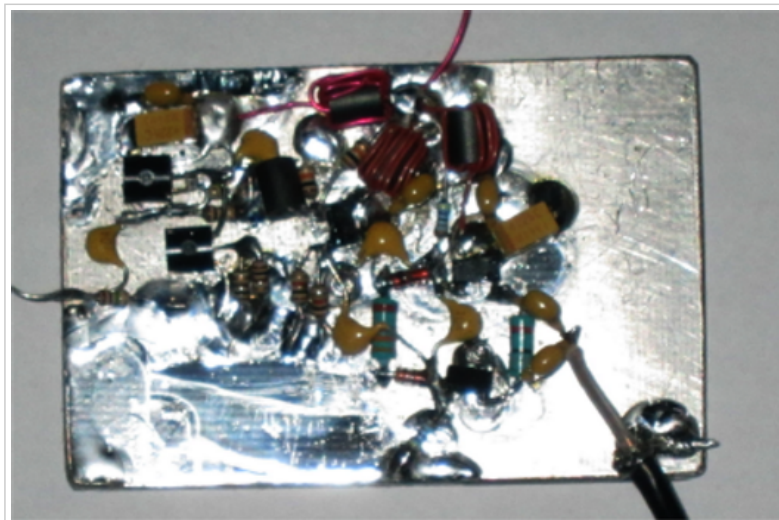
Frequency / gain plot of Trask antenna vs. PA0RDT. Both antennas using 10mH Bias and DC injection chokes.



This is one of my favorites so far in terms of ease of construction vs. performance.

Clifton Labs Active monopole

Similar to one of Chris Trask's designs but with a few additional modifications.



<http://www.cliftonlaboratories.com/Documents/Z1501D%20Instruction%20Manual-01.pdf>

I modified this by using a FET Constant current source in place of the Input FET source resistor, and set the current at about 20mA. I also omitted the choke in the emitter of the buffer stage, as this seems to be an unnecessary complication. Chris Trask has also added this modification to one of his designs.

The ferrite beads shown in the circuit diagram. Are optimised for the frequency range in use, and are used to define the upper operating frequency. I omitted them. As standard single hole beads will not perform the same function. They need about three turns of wire on them to give a similar characteristic.

<http://lairdtech.thomasnet.com/browser?&plpver=10&prodid=3001393&itemid=5762&assetid=3909>

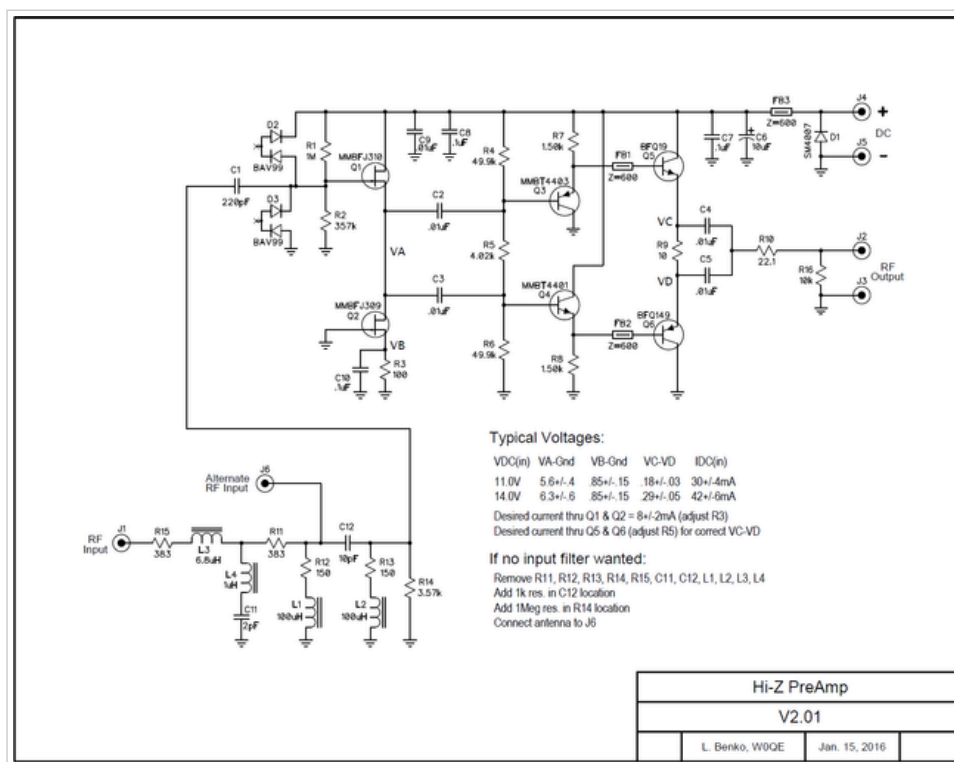
This circuit seems to work very well, and has an extremely flat frequency response from about 10KHz upto >180MHz.

IMD performance seems reasonably good, but I still need to measure this properly.

W0QE Active Monopole Preamplifier

W0QE has a lot of interesting information on his website, including an amplifier that is suited for use as an active monopole.

http://www.w0qe.com/Projects/active_monopole_amplifier.html



Nordholt Antenna

A predecessor of the PA0RDT, Clifton Labs and Chris Trask designs.

More details can be found here

http://www.gunthard-kraus.de/DSP/Dsp_CD/VLF-Technique_and_Software_and_Activity/Active%20Antennas/Another%20Approach%20to%20Active%20antennas/

The patent document can be found here

http://worldwide.espacenet.com/publicationDetails/originalDocument?FT=D&date=19840307&DB=EPODOC&locale=en_EP&CC=GB&NR=2079064B&KC=B&ND=4

NASA Designs

Chris Moulding of Cross Country Wireless pointed out these designs to me. Most are easy to build. But the the last link may be a bit more problematic as it's a superconducting loop !

<http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19790011925.pdf>

<http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19940020710.pdf>

Thanks to Robert, for locating the new NASA link shown below)

<https://www.cs.odu.edu/~mln/ltrs-pdfs/NASA-2003-tm212647.pdf>

Note this link is still broken - can anyone provide a new one ?

http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19800076180_1980076180.pdf

James, KE8AXZ, has provided this link as a possible alternative.

https://www.mikrocontroller.net/attachment/256415/Active_antenna_coupler_for_VLF.pdf

Datong AD270/370

<https://sites.google.com/site/datongarchive2/ad270ad370>

I have one of these working on top of my works QTH (and another sitting around in my garage) that I use for making remote TX antenna field strength measurements. Although it's supposed to be a balanced antenna, it is not immune from common mode noise. However it gives very repeatable results, in terms of long term amplitude stability.

Chris Trask has analysed this design and produced his own circuit.

<http://home.earthlink.net/~chrstrask/Active%20Dipole%20Antenna.pdf>

I've been building a broadband version of Chris Trask's remote tuned design. Which I hoped would outperform the Datong. However at the moment I'm having a few problems getting the circuit to function correctly. The individual stages work OK. But when they are connected together the frequency response is not particularly flat. A suggestion is that the cumulative phase / time delays through the cascaded stages. May be messing up the feedback circuitry. I've spent several days on this so far. So I've put it aside for a while and will revisit it later.

Cross Country Wireless HF Active Antenna

This is a relatively new design of balanced active antenna. Which is being produced by Chris Moulding of Cross Country Wireless.

http://www.crosscountrywireless.net/active_antenna.html

I have an early production version, which works well. Performance is comparable to the Datong AD 270/370 (which is no longer available).

One interesting feature is that the RF 'head' and receiver interface are connected together via CAT5 multi-core Ethernet cable, rather than coax. Chris claims that this helps to reduce the incidence of common mode noise pickup on the interconnecting cable. I was not able to fully verify this. But the design did seem less susceptible to this problem than the Datong models.

Dressler ARA-2000

<http://www.dd1us.de/Downloads/Dressler%20ARA-2000%20what%20is%20inside%20rev3.pdf>

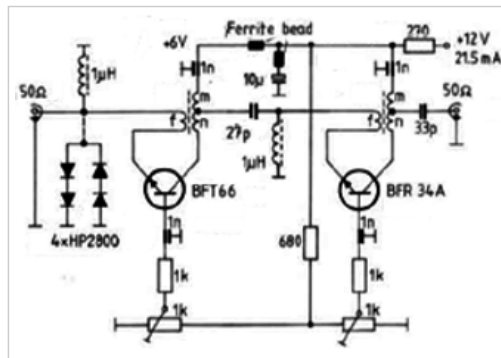
<https://apollo.open-resource.org/mission:log:2012:08:02:active-wideband-receiver-antenna-for-sdr>

I had previously built a version of the ARA-500 (50-500MHz) which used a fat printed circuit board bi-conical style dipole.

This used a broadband balun on the input of a BFT66 bipolar transistor RF amplifier with ferrite transformer derived negative feedback.

The circuit was similar to a broadband pre-amplifier design originally published in the German 'VHF Communications' magazine 1978 Q1 Pages 30 ? 36. Entitled ?A New Type of Pre-amplifier for 145 MHz and 435 MHz Receivers? By M Martin, DJ7VY.

The MuTeK BBBA 500u also used a similar circuit, but only using one stage of amplification. This provides a gain of about 10dB.



The later versions of Dressler such as the ARA-2000. Use FETs or broadband amplifier MIMIC's of various types and a strange helically wound antenna element constructed from foil tape.

<http://www.dd1us.de/Downloads/Dressler%20ARA-2000%20what%20is%20inside%20rev3.pdf>

Here's another analysis and a suggestion for an improved version of the Dressler

<https://apollo.open-resource.org/mission:log:2012:08:02:active-wideband-receiver-antenna-for-sdr>

I'm now trying to get hold of a small quantity of RF3827DS RF amplifier chips to experiment with and maybe try building something like a better version of the Dressler Active antenna. This is proving to be somewhat difficult. So if anyone can help please drop me a line.

<http://www.rfmd.com/CS/Documents/RF3827DS.pdf>

Lots of other active antenna links can be found here

http://www.rsl.ku.edu/~eecs501/active_antennas/

SSB Electronics LNA-3000 Broadband masthead pre-amplifier (now discontinued).

http://www.rigpix.com/accessories/ssb_lna3000.htm

Although not strictly an active antenna, this low noise broadband amplifier proved to be a useful addition to a Discone or Bicone antenna and often dramatically improved reception on the VHF and UHF bands.

Faulty units often appear on the surplus market, but it is not immediately obvious which semiconductor devices were used in the original design.

http://www.dd1us.de/Downloads/lina-3000_v_1_1.pdf

However I have successfully repaired units by replacing the two stacked semiconductors with MGF1302 Low Noise GaAs Fet's.

<http://www.mitsubishielectric-mesh.com/products/pdf/mgf1302.pdf>

When working correctly the source load resistor in the circuit has a value of 33R (3 x 100R in parallel) which provides a voltage drop of 4.16v with a bias current of approx 126mA for the two devices (63mA per device).

The amplifier typically provides a gain of approx 12dB, with a low noise figure and good strong handling performance.

Active Loop Antennas

The main factors affecting the performance of broadband active loop antennas are the loop size, loop inductance, loop & amplifier balance, amplifier input impedance, amplifier noise figure and amplifier strong signal handling performance. The latter is especially important when strong signals are present.

Assuming that the loop & amplifier balance (common mode rejection) and amplifier noise figure and strong signal handling characteristics are adequate, then for most users the main factors become loop size, loop inductance, and amplifier input impedance. Generally speaking the lower the loop inductance for a given size loop, the better the performance.

Some additional notes on the subject can be found on this separate web page.

<https://www.g8jnj.net/loop-inductance>

Wellbrook ALA1530 and variants

http://www.wellbrook.uk.com/Loop_Antennas

The Wellbrook loop is a very popular commercial loop antenna that works very well. However if it becomes faulty Wellbrook and only supply a limited number of spares. The amplifier module is potted in resin and so is very difficult to repair.

This website :-

https://www.george-smart.co.uk/wiki/WellGood_Loop

contains a detailed tear down of the Wellbrook loop amplifier including a circuit diagram.

It's well worth a look if you are considering buying a Wellbrook loop, or have one that has become faulty.

PA3GZK's WIDE BAND ACTIVE LOOP RECEIVING ANTENNA

<http://pa0fri.home.xs4all.nl/Ant/Active%20antenna/Active%20receiving%20%20loop%20antenna%20eng.htm>

I like the neat construction method that uses 15mm copper pipe and irrigation pipe tees. But I thought that this is a very simple design would benefit from a more recent type of amplifier chip. The PGA-103+ would be a good candidate to try in place of the outdated INA-02186.

Tried a quick lash up using some RG58 test leads of odd lengths that were lying around to form a loop in the shack, and it works quite well. Especially considering it's sitting amongst all the PC's and noise generators. The loop size needs optimising, but I can already get quite good nulls and the loop isn't anywhere near properly balanced. I think it would work really well outside.

Although the antenna works to a certain extent there are a few problems.

The screened loop has several resonances within the required frequency range at around 4MHz, 20MHz and 40MHz which mess up the gain frequency response. It may be possible to shift these to less problematic frequencies by using an unscreened or smaller screened loop.

Another problem is that the PGA-103+ is designed for use as a wideband 'gain block' for use in 50 Ohm systems. However it's input impedance starts to rise at frequencies below 50MHz. So it's well suited for use in a 'voltage' probe E-Field antenna. But less suited for use as a 'magnetic' H-Field loop amplifier which needs to have a very low value of input impedance.

There is big mismatch between the loop impedance of low R high XC and 1K input impedance of the PGA-103+. It's possible to improve this by adding resistive damping to the PGA input, but it reduces the overall gain dramatically. I've also tried a 12.5 to 50 transformer which helps, but a lot of other equalisation would be required to get anything near an flat response curve. I suspect that this is likely to be a problem with the original design too.

Norton amplifiers have an input impedance of around 2 ohms whereas the PGA-103+ has an input impedance of around 1K ohm. So the PGA-103+ will work as a loop amplifier, but the mismatch loss means that the noise figure and gain flatness is not as good as it really needs to be for this application.

Loop amplifier designs by Chris Trask and Clifton Laboratories are good sources for further inspiration.

One further line of investigation is to use two PGA-103+'s to form a balanced amplifier. One connected at each end of the loop with their outputs combined via a 0/180 phase impedance transformer to 50 Ohms. A bit like the G8CQK simple active loop shown below.

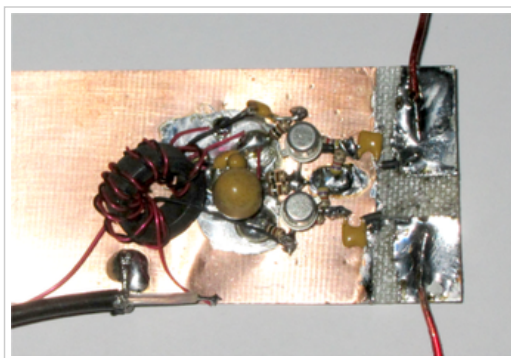
I've also thought about putting the amp in a die-cast box and attaching the ends of the coax loop with something like 'F' or TNC connectors. That way different size loops could be swapped as required or the loop could be easily broken down for portable / storage purposes.

M0AYF simple two transistor active loop

<http://www.gsl.net/m0ayf/active-loop-receiving-antenna.html>

Very easy to build. Reasonable noise rejection. 10dB variation in frequency response between 1.8MHz & 30MHz with peak at 10MHz.

Performance is reasonable but IP3 is quite poor. So only a small loop can really be used with it.



PE1KTH broadband loop

<http://dijkjj.home.xs4all.nl/download/bq-c-wl1030xx.pdf>

I have now acquired the special op-amps that are required for this design. But they seem to be very sensitive to mishandling. Especially if soldered by hand.

I've already blown up six of them, so I wouldn't recommend this one as I think there are better alternatives.

LZ1AQ - Amplifier for Small Magnetic and Electric Receiving Wideband Antennas

This is an excellent commercial product, model number AAA-1C. A very interesting design which can be remotely switched to operate as either an active loop or dipole.

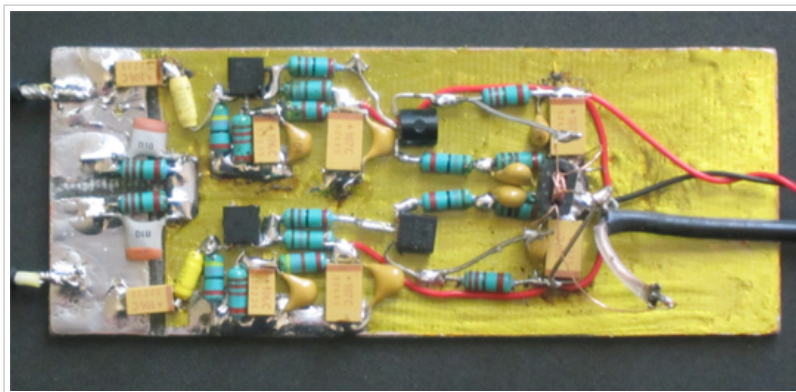
<http://active-antenna.eu/>

Here's my crossed loop array using the LZ1AQ kit. The loops are 1m in diameter and made from LDF4-50 semi rigid coax.

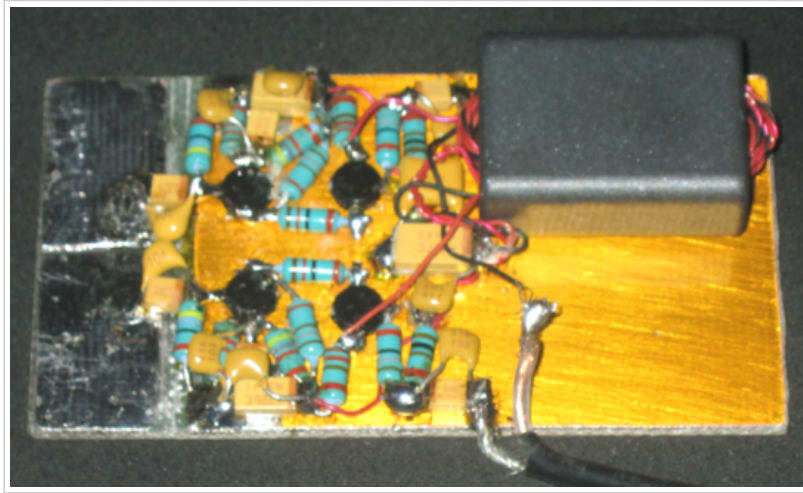


The basic loop amplifier circuit is shown on LZ1AQ's webpage <http://www.lz1aq.signacor.com/docs/wsm1/wideband-active-sm-loop-antenna.htm>

It's easy enough to build, here's my first version built on a bare PCB covered in Kapton tape, which I photographed whilst experimenting with different ratio output transformers.



And this is the current version I'm using.



I omitted the Input filter, 10v regulator and used a large ferrite output transformer (to avoid DC saturation) with a coax feed and external bias Tee rather than using CAT5 cable.

The transistors are matched pairs of MRF581's which give a very flat frequency response, but 2N2222A's can be used for the input stage.

To get the best from this design you need to use a loop with as low a value of inductance as possible.

This is what I'm currently using. It's 1m in diameter and is 0.3m wide. It has an inductance of approximately 1.6uH.



There is a wealth of useful design information on both of LZ1AQ's websites that are relevant for anyone contemplating the construction of an active loop antenna.

<http://www.lz1aq.signacor.com/>

<http://active-antenna.eu/application-notes/>

The DL4ZAO website also contains some useful circuits that are very similar to those of LZ1AQ.

Note that the documents PDF copies written in German, so Google translate will not work. However it is still possible to understand the diagrams etc.

http://www.dl4zao.de/downloads/Whip_und_Loop_Aktivantennen_fuer_den_Empfang.pdf

Stampfl Blue Wave and Red Fox loop amplifiers

These designs are popular in parts of Europe and basically consist of half of a LZ1AQ circuit. They use a common base transistor as the loop amplifier and a common emitter transistor as a buffer stage and line driver.

<https://www.heinzstampfl.ch/en/produkt/blue-wave-active-antenna-0-05-30mhz/>

A comparison can be found here

<https://www.fenu-radio.ch/Bluewave-Red-Fox-en.htm>

Considering the price of the Stampfl, a ready built LZ1AQ looks like much better value for money and is a good basis for lots of experimentation.

MFJ-1886 active loop antenna

<http://www.mfjenterprises.com/Product.php?productid=MFJ-1886>

This design uses two Mini-Circuits GALI-74+ devices in a push pull circuit with a balanced output transformer.

<https://www2.minicircuits.com/pdfs/GALI-74+.pdf>

The handbook can be found here

<http://www.mfjenterprises.com/Downloads/index.php?productid=MFJ-1886&filename=MFJ-1886.pdf&company=mfj>

and the circuit diagram can be found here.

<http://www.mfjenterprises.com/Downloads/index.php?productid=MFJ-1886&filename=1886%203.8%20schematic.jpg&company=mfj>

I haven't (so far) been able to find any specifications relating to the intermodulation performance of this design.

Individual GALI-74+ devices have published values of +19.2 dBm typ. output power at 0.1 GHz and an IP3, +38 dBm at 0.1 GHz, so the LZ1AQ and Wellbrook designs are likely to be better in this respect.

Note that the higher value of amplifier input impedance may result in this design being a better performer on the HF bands especially at frequencies >10MHz.

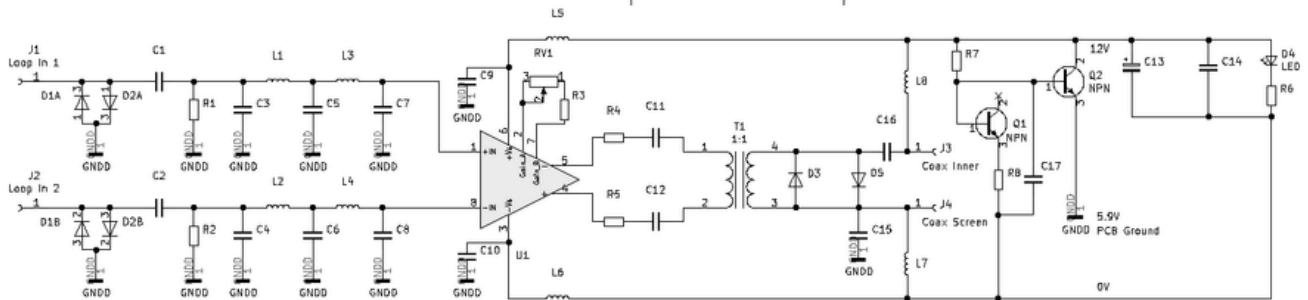
MLA-30 'Megaloop'

This is a Chinese 'Look Alike' of the Bonito Nti Megaloop but only costs about 1/10th of the price, so as you would expect, although it look the same it's a radically different beast.

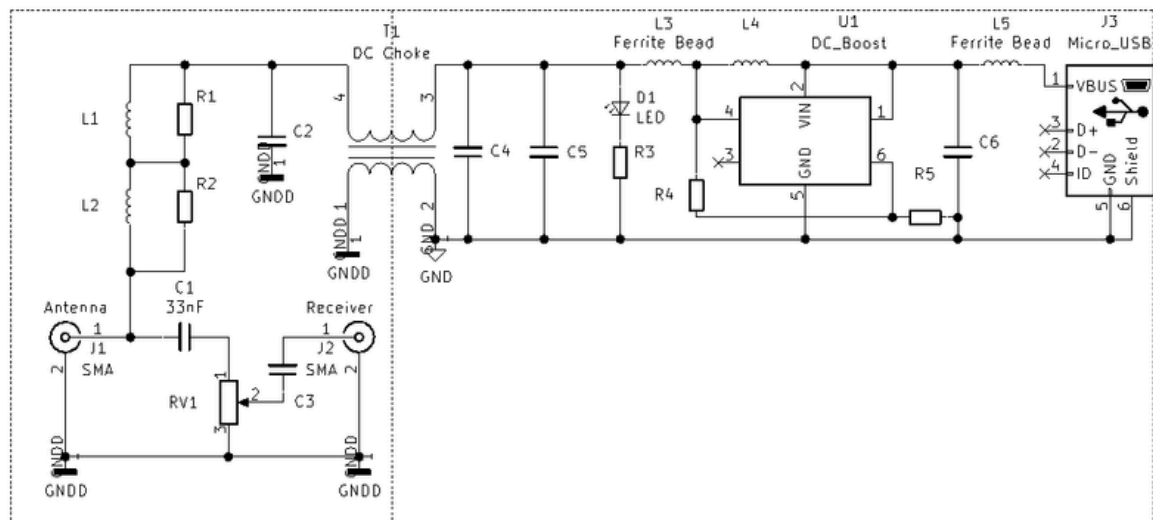
Here's a circuit diagram that I reverse engineered from a set of PCB's that Matt, M0LMK managed to extract from the potting compound.

<https://www.m0lmk.co.uk/2019/09/12/inside-the-mla-30-active-loop-antenna/>

MLA-30 Loop Amplifier



MLA-30 Biasing Tee



It's based around the Texas TL592B chip, which is a two-stage video amplifier with differential inputs and differential outputs.

<http://www.ti.com/lit/ds/symlink/tl592b.pdf>

So as you may expect, it's not going to have stellar performance in this application.

The actual design is probably based on Charles Wenzel's "Active 3-30 MHz Hula-Loop Antenna for Shortwave"

<http://www.techlib.com/electronics/antennas.html>

Measured Performance

Gain

Max 30dB
Min 10dB

Input impedance

1.5K Ohm at 1MHz
1.4K Ohm at 10MHz
600 Ohm at 20MHz
450 Ohm at 30MHz

OIP2 approx +46dBm
OIP3 approx +20dBm
PSAT approx -3dBm

Common mode rejection

PCB ground as reference approx 20dB
 Coax screen as reference >55dB

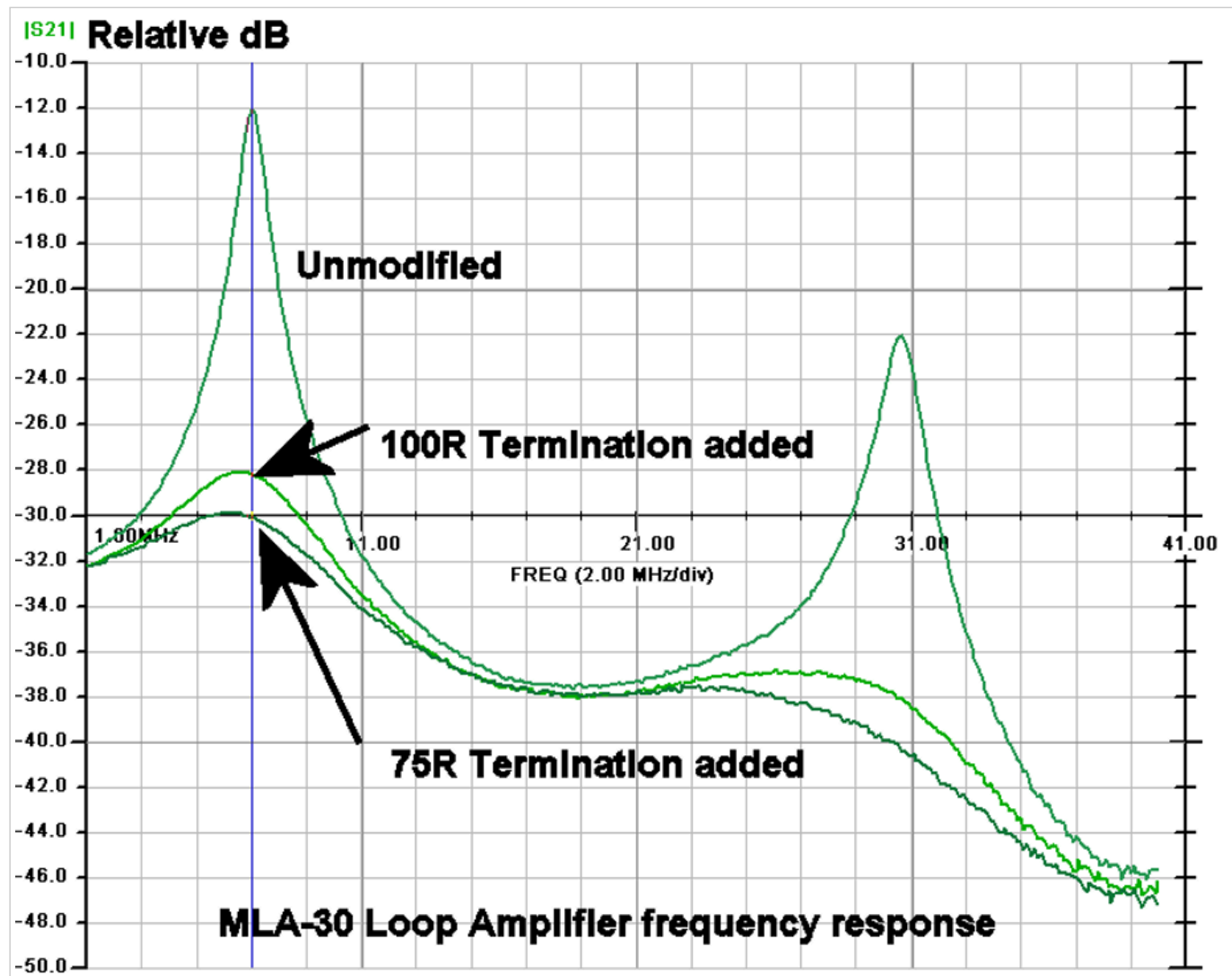
Noise figure

approx 12dB

Whilst testing the common mode rejection by shorting the two inputs together, the circuit would oscillate and produce a -10dB signal at around 160MHz. So it isn't unconditionally stable.

The designer has really slipped up by using a 30MHz input Low Pass Filter that is designed for 50 Ohm termination impedances. In this circuit where a low impedance loop is the source and an amplifier having a single ended input impedance in the region of a few hundred Ohms is the load, the amplitude / frequency response curve is all over the place.

The following graph was taken with a low value of source impedance in order to better simulate a loop.



As you can see the big problem is that under certain conditions the unmodified amplifier can have a 20dB higher level of gain at around 7MHz, which is bad news, especially in Europe, as this is where all the very strong broadcast stations appear at night.

In order to try and level of the frequency response, I tried adding various values of terminating resistors between the amplifier chip Pin 1 and the PCB ground and Pin 8 and the PCB ground in an attempt to improve the match (although this is only possible if the potting compound can be safely removed). It looks like 75 or 100 Ohms is about the optimum (50 Ohms rolls the gain off too rapidly at 30MHz) however it does reduce the overall gain, but this can be increased in order to compensate.

Most designs of active loop antenna use an amplifier with an input impedance in the region of 1 to 100 Ohms. This is in order to maximise the signal to noise performance and help to maintain loop balance. In this design the input impedance is much higher >450Ohms, which coupled with the imperfect input 30MHz low Pass Filter network, means that the loop sensitivity is likely to be quite poor and the performance at specific frequencies will be unpredictable.

Up in the sky it's a pretty average performer, and would only really be suitable for low end receivers such as an RTL dongle in direct sampling mode. as the noise floor is about 20dB higher than any other active antenna I've tried, and increasing the amplifier gain doesn't help improve the Signal to Noise ratio.

There's also a lot of unwanted noise around 60 & 120KHz emanating from the DC-DC switcher in the Biasing Tee. This can be dramatically reduced by adding a 1000uF capacitor across C2 in the biasing tee circuit.

Based on my tests, I wouldn't recommend it, maybe it's better than nothing, but it's definitely not a Bonito Nti Megaloop.

Ramsey Electronics - Signal Magnet Active Ferrite Rod Antenna

<http://www.ramseyelectronics.com/downloads/manuals/sm100.pdf>

I like this as it uses a varicap tuned ferrite rod. Which has an electrostatic screen wrapped around it.

No circuit is included in the manual, but it's possible to figure it out from the PCB layout and Parts list.

Broadband Amplifiers

Two of the best designs I've found are shown below.

Norton Lossless Feedback

Norton Amplifiers use a transformer to provide lossless negative feedback which linearises the amplifier and improves the intermodulation performance.

Most of the designs on the web are based on an article published by Dr. David E. Norton in the May 1975 Microwave Journal under the title, "High dynamic range transistor amplifiers using loss less feedback."

Practical designs have been produced by Chris Trask and Dallas Lankford and detailed design information can be found [here](#)

<http://www.thegleam.com/ke5fx/norton/lankford.pdf>

Here's an example of a push pull Norton amplifier I've built using MRF581 transistors

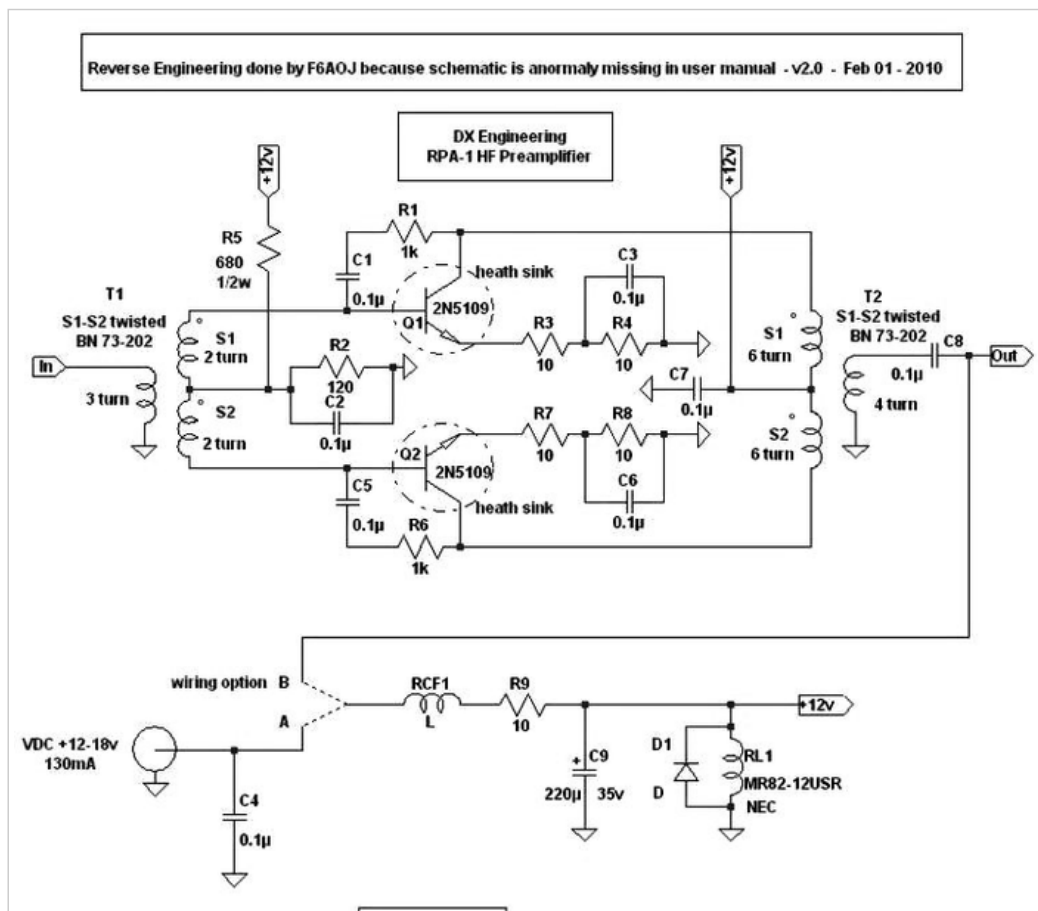


DXE RPA-1

Another type of design using conventional feedback techniques is based on the [DX Engineering RPA-1 Pre-amplifier](#) which is very popular for use with low gain antennas such as Pennants, flags, and K9AY loops.

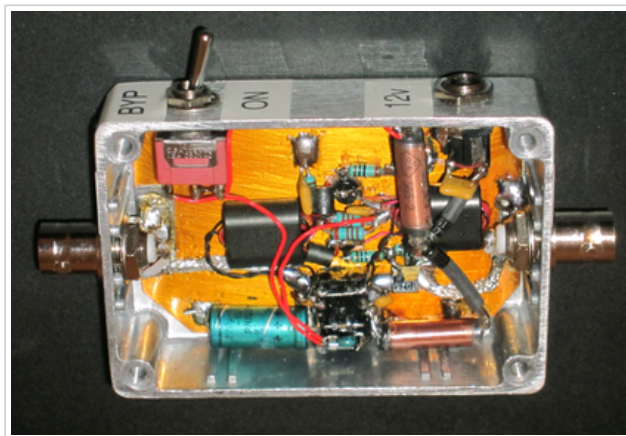
The circuit has been reverse engineered by Jeff, F6AOJ, and published on his website http://f6aoj.ao-journal.com/crbst_236.html

My thanks to Jeff for allowing me to include this circuit diagram.



I built my copy using some MRF581 transistors which I had to hand.

The only modifications to the circuit being the addition of single hole ferrite beads to the transistor base connections and a reduction of C3 & C6 from 100nF to 1nF, which I found produced a flatter frequency response which was usable from 50KHz to 50MHz.



I also added some bias tee chokes so that I could remotely power the amplifier via the coax if required.

The intermodulation performance seemed to be slightly better than the previous Norton amplifier, and I found that it was a lot easier to construct.

This is my current preferred design for use as a distribution amplifier.

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